

Seismic Issues for Nuclear Power Plants

Nuclear power plants are built to withstand environmental hazards, including earthquakes. Even those plants that are located outside of areas with extensive seismic activity are designed for safety in the event of such a natural disaster. The Nuclear Regulatory Commission (NRC) requires all of its licensees to take seismic activity into account when designing and maintaining its nuclear power plants. When new seismic hazard information becomes available, the NRC evaluates the new data and models and determines if any changes are needed at plants. The newest seismic data suggests that although the potential seismic hazard at some nuclear power plants in central and eastern states may have increased beyond previous estimates, all operating nuclear plants remain safe with no need for immediate action.

Background

The agency requires plant designs to withstand the effects of natural phenomena including earthquakes (i.e., seismic events). The agency's requirements, including General Design Criteria for licensing a plant, are described in Title 10 of the *Code of Federal Regulations* (10 CFR). These license requirements include traditional engineering practices such as "safety margins." Practices such as these add an extra element of safety into design, construction, and operations.

The NRC has always required licensees to design, operate, and maintain safety-significant structures, systems, and components to withstand the effects of earthquakes and to maintain the capability to perform their intended safety functions. The agency ensures these requirements are satisfied through the licensing, reactor oversight, and enforcement processes.

Earthquake (or Seismic) Hazard

The NRC requires that safety-significant structures, systems, and components be designed to take into account:

- The most severe natural phenomena historically reported for the site and surrounding area. The NRC then adds a margin for error to account for the limited historical data accuracy;
- Appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena; and
- The importance of the safety functions to be performed.

The U.S. Geological Survey (USGS) Web site provides general information about earthquakes (<http://earthquake.usgs.gov/learning/index.php>). An earthquake releases energy that radiates from the fault and causes ground movement. As the ground moves, objects such as nuclear power plant structures on or in the ground also move. The nature of the movement depends on how the earthquake releases energy and location. The intensity of an earthquake can be characterized by both the frequency of the shaking and by the acceleration of the ground at the plant. These characteristics describe how the energy released from the earthquake impacts the plant's buildings as well as the systems and components that are housed and supported by those buildings.

Earthquake characteristics provide information used in designing existing nuclear plants. The frequency of the shaking is measured in cycles per second (or Hz), and the acceleration is typically expressed as some fraction of the acceleration of gravity, which is about 32.2 feet per second per second (ft/s²). For example, an acceleration of 0.15 g (15 percent of the acceleration of gravity) is about equal to an acceleration of 5 ft/s².

Seismic Safety Assessment

The licensing bases for existing nuclear power plants considered historical data at each site. This data is used to determine design basis loads from the area's maximum credible earthquake, with an additional margin included. In Generic Letter 88-20, the NRC required existing plants to assess their potential vulnerability to earthquake events, including those that might exceed the design basis, as part of the Individual Plant Examination of External Events Program. This process was intended to examine the available safety margins of existing plants beyond the design basis (Safe Shutdown Earthquake) and to report on certain modifications of identified seismic vulnerabilities.

Today, the NRC utilizes a risk-informed regulatory approach, including insights from probabilistic assessments and traditional deterministic engineering methods to make regulatory decisions about existing plants (e.g., licensing amendment decisions). Any new nuclear plant the NRC licenses will use a probabilistic, performance-based approach to establish the plant's seismic hazard and the seismic loads for the plant's design basis.

Additional Measures Following Sept. 11, 2001

Following the events of September 11, 2001, NRC required all nuclear plant licensees to take additional steps to protect public health and safety in the event of a large fire or explosion. If needed, these additional steps could also be used during natural phenomena such as earthquakes, tornadoes, floods, and tsunamis. In general, these additional steps are plans, procedures, and pre-staged equipment whose intent is to minimize the effects of adverse events. In accordance with NRC regulations, all nuclear power plants are required to maintain or restore cooling for the reactor core, containment building, and spent fuel pool under the circumstances associated with a large fire or explosion. These requirements include using existing or readily available equipment and personnel, having strategies for firefighting, operations to minimize fuel damage, and actions to minimize radiological release to the environment.

Evolving Knowledge about Earthquakes

The central and eastern United States (CEUS) is generally an area of low to moderate earthquake hazard with few active faults in contrast to the western United States. Even so, in 1811–1812, three major earthquakes (Magnitude 7 to 7.7 on the commonly used Richter scale) shook much of the CEUS. These earthquakes occurred near the town of New Madrid, M.O. In 1886, a large earthquake (Richter scale magnitude of about 7) occurred near Charleston, S.C. This earthquake caused extensive damage and was felt in most of the eastern United States. Geologists are aware of these historic occurrences, and knowledge of such earthquakes was taken into account in plant design and analysis.

The NRC regularly reviews new information on earthquake source and ground motion models. For example, the NRC reviewed updated earthquake information provided by applicants in support of Early Site Permits for new reactors. This additional information included new models to estimate earthquake ground motion and updated models for earthquake sources in seismic regions such as eastern Tennessee and around both Charleston and New Madrid.

The NRC examined 2008 earthquake-related information to assess potential safety implications for nuclear power plants in central and eastern states. Analysis of these updates indicated slight increases to earthquake hazard estimates for some plants in the CEUS. The NRC also reviewed and evaluated recent USGS earthquake hazard estimates for the CEUS that are used for building code applications outside of plant licensing. These reviews showed that the seismic hazard estimates at some current CEUS operating sites may potentially be slightly higher than what was expected during design and previous evaluations, although there is adequate protection at all plants.

NRC Response to Increased Estimated CEUS Earthquake Hazards

The NRC began assessing the safety implications of increased plant earthquake hazards in 2005 when the staff recommended examining the new CEUS earthquake hazard information under the Generic Issues Program (GIP). The NRC staff identified the issue as GI-199 and completed a limited scope screening analysis for the seismic issue in December 2007, to decide whether additional review is needed. The screening compared the new seismic data with earlier seismic evaluations conducted by the NRC staff. **This analysis confirmed that operating nuclear power plants remain safe with no need for immediate action.** The assessment also found that, although overall seismic risk remains low, some seismic hazard estimates have increased and warrant further attention. In September 2010, NRC issued a Safety/Risk Assessment report and an Information Notice (<http://www.nrc.gov/reading-rm/doc-collections/generic-issues/gis-in-implementation/>) to inform stakeholders of the assessment results.

The NRC is developing a Generic Letter (GL) to request information from all U.S. nuclear plants. The GL will be issued in draft form to support a public meeting in late spring 2011. NRC expects to issue the GL by the end of 2011, near the time when new seismic models will become available. These new seismic models are being developed by NRC, the U.S. Department of Energy, and the Electric Power Research Institute and will be reviewed by the USGS. The NRC expects to receive information from the GL in 2012 and will review it to determine whether any plant improvements are needed.

Information regarding this generic issue and the GIP in general is available at <http://www.nrc.gov/about-nrc/regulatory/gen-issues.html>.

Inspections Following Japan Event

The NRC is not currently performing inspections that are directly related to GI-199. However, on March 23, 2011, the NRC directed its inspectors to assess the actions taken by nuclear plant licensees in response to events at the Fukushima Daiichi nuclear station in Japan. NRC inspectors will perform inspections to verify that important equipment and materials are adequate and properly staged, tested, and maintained in order to respond to a severe earthquake, flooding event, or loss of all electrical power. Inspections were completed by end of April 2011. The inspection reports are publicly available for each plant on the NRC website at <http://www.nrc.gov/NRR/OVERSIGHT/ASSESS/follow-up-rpts.html>.

To read more about risk-related NRC policy, see the Probabilistic Risk Assessment Fact Sheet (<http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/probabilistic-risk-asses.html>) and Nuclear Reactor Risk (<http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/reactor-risk.html>). Each provides more information on the use of probability in evaluating hazards (including earthquakes) and their potential impact on plant safety margins. Questions and answers on the March 2011 earthquake and tsunami are available at <http://www.nrc.gov/japan/faqs-related-to-japan.pdf>.